Fremantle's Bridge Heritage

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SUMMARY: Historical records, contemporary drawings and photographs have been used to describe the eight bridges which have been built over the Swan River in Fremantle since 1863. The paper outlines the early history of the Swan River Settlement, including the events that led to the arrival of convicts in 1850, and describes how this enabled the first bridge at Fremantle to be built. It then shows how the construction of subsequent bridges was closely related to political and economic events in Western Australia and the development of Fremantle as the principal port for the State. The various bridges reflect developments in bridge technology since 1863 and the paper concludes that, while it has not been practical to preserve the structures themselves, their engineering heritage can be preserved by assembling and recording the available written and visual records.

1. INTRODUCTION

Eight bridges have been built over the Swan River in Fremantle since 1863 and, although only three of these now exist, they are a significant part of the heritage of the port of Fremantle.

178 years ago, in May 1829, Captain Charles Fremantle arrived in HMS Challenger at the mouth of the Swan River and proceeded to annex the western third of Australia on behalf of the British Government[1]. One month later, in June 1829, the sailing ship Parmelia arrived with Captain James Stirling and his official party on board with the aim of establishing the first colony of free men in Australia.

When James Stirling established the Swan River settlement in June 1829 he was anxious to locate the capital of the new colony beyond the range of naval bombardment and therefore took the unusual decision of founding two initial townships, a port settlement on the southern side of the Swan River, which he named Fremantle, and an administrative capital on the north bank of the river below Mount Eliza, which he named Perth. By siting Fremantle and Perth on opposite banks of the Swan River Governor Stirling created an immediate need for bridges across the river to connect the two townsites.

Figure 1. *The Roundhouse at Fremantle 1832*

Figure 1 is an illustration of early Fremantle taken from a watercolour by Jane Currie and shows the conditions at Fremantle shortly after it was founded, with simple houses located in the native bush and the only building of significance the Roundhouse Prison, built on Arthur Head by Henry Reveley in 1831.

The necessary technical resources and money required to build bridges were not available during the early years of the colony and the only way of crossing the river was by boat. The lack of a bridge had tragic consequences for a Dr John Whatley and Captain Stryan in 1830 when they tried to ferry a live cow across the river at the East Fremantle site of Preston Point in a small boat. When, not surprisingly, the boat capsized both men were drowned.

A land route between Perth and Fremantle only became available in December 1849, 20 years after the first settlers arrived in the colony, after the construction of a bridge over the Swan River at the Causeway in May 1843 and a bridge over the Canning River in December 1849[2]. It was however a further 14 years before a bridge was built across the Swan River in Fremantle and then only after a major change had occurred in the colony.

2. THE ARRIVAL OF CONVICTS

This change was the establishment of a penal settlement in Western Australia in 1850. During the 1840's the colony suffered from both a general economic recession in Australia and conditions peculiar to Western Australia. After the hardships of the early settlers became known in Britain the flow of migrants to the colony reduced and eventually there was a net reduction in population as people left for either South Australia or the other colonies. There was therefore a shortage of cheap labour and, because prices for agricultural produce were low, there was also a great shortage of money.

Many colonists strongly opposed the introduction of convicts and the subject was hotly debated in the local press for many months. The controversy has been extensively documented by both Hasluck[3] and Stannage[4] and those in favour of convicts eventually won the day. In February 1849, after receiving a petition from members of the York Agricultural Society and leading

merchants in Fremantle and Perth, Governor Fitzgerald requested the British Government to establish a penal settlement in Western Australia. As British gaols were overcrowded with prisoners and transportation to New South Wales had ceased in 1840, the British Government granted the request immediately and on the 1st June 1850 the ship 'Scindian' arrived with 75 convicts and 50 pensioner guards and their families on board, under the charge of Capt. E.Y.W. Henderson.

When Capt. Henderson arrived in the colony he was forced to lease various premises to accommodate his 70 convicts and realised it was essential to build a proper prison as soon as possible. He therefore sent an urgent request to England for some Royal Engineers to prepare plans and supervise the convicts on construction work. On 23rd December 1851 the 20th Company of Sappers and Miners arrived[5]. The Royal Engineers were immediately deployed on supervising convicts in the construction of buildings, roads and bridges throughout the southwest of the State. In the twelve years up to 1862 the convict labour force numbered approximately 1000 men and during that period they built 239 bridges, and many other structures

The two men responsible for the design and construction of the bridge were Captain Grain, R.E., and James Manning, a Clerk of Works attached to the Imperial Establishment who had accompanied Captain Henderson R.E. out to Western Australia in the 'Scindian' in 1850. Based on contemporary reports and drawings I think it most probable that James Manning carried the major technical responsibility for the bridge. He had trained in England as a civil engineer and, as Clerk of Works in the Ordnance Department, later became responsible for the construction and maintenance of jetties and bridges throughout the colony.

The bridge had a total length of 287 metres and consisted of two navigation spans, each of 13.7 metres, and 33 other spans of approximately 8 metres. The width of the bridge deck was 5.5 metres. The most remarkable feature of the structure was its great height to allow barges to sail under the bridge. The two navigation spans were 13.4 metres above high water level.

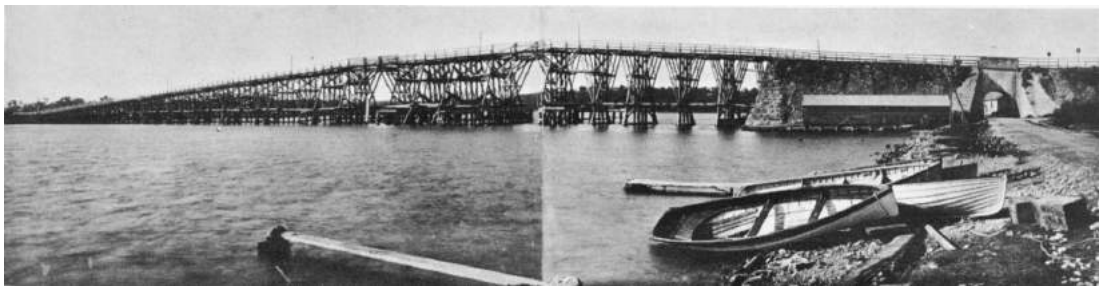

Figure 2. *North Fremantle Bridge*
(Courtesy of the Battye Library, Perth)

3. NORTH FREMANTLE BRIDGE

Construction of the North Fremantle or High Level Bridge, which is shown in Figure 2, was finally authorised by Governor Hampton in 1863 and was by far the largest and most difficult bridge built by the Royal Engineers with convict labour. In addition to the very long and high timber bridge there was a massive earthworks embankment at the southern end of the bridge and a masonry arch bridge, which you can see on the right of Figure 2, to provide access under the embankment.

Work commenced in May 1863 and the bridge was opened to traffic in November 1866 but was not finally completed until October 1867, a period of four and a half years. During the first two years of construction the average number of convicts working on the bridge was 48, of whom 28 worked in chain gangs on the embankment. Some skilled tradesmen were also employed on the bridge.

Figure 3. *High Level Bridge*
(Courtesy Fremantle City Library)

Figure 3 is another view of the bridge which illustrates the enormous amount of timber used in the piers. The method of constructing the bridge in order to achieve the required height for navigation clearance was quite ingenious and is illustrated in Figures 4 to 8, which are

reproduced from detailed drawings prepared by Manning.

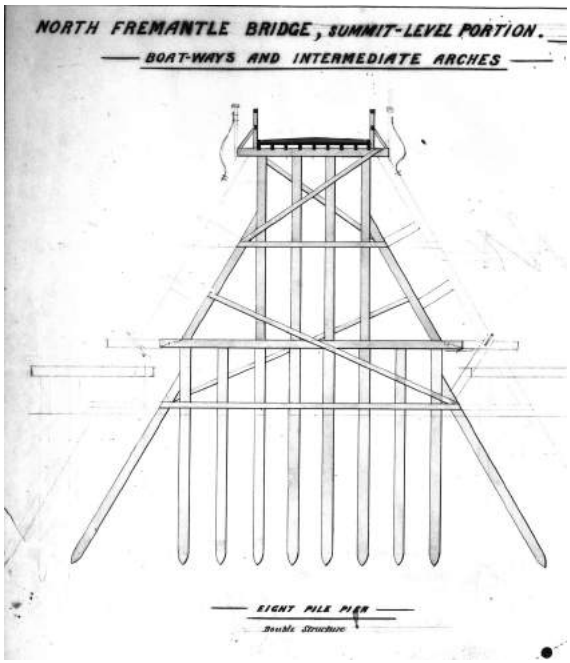

Figure 4. *Main Bridge Pier*
(Courtesy of the Battye Library, Perth)

Figure 4 shows one of the main piers at the summit level of the bridge which was constructed in two stages. The lower stage consisted of a single line of eight 450 mm diameter round timber piles and two raking piles which were driven approximately 3 metres through the river bed into the underlying limestone rock. These piles were extended 4.3 metres above high water level, where they were joined into a 350x350 mm lower cap beam. The second stage consisted of a single line of four 400 mm round timber columns with cross bracing which was constructed up to deck level.

The ends of both the round timber piles and columns were fashioned into rectangular tenons which were then slotted into morticed holes cut into the lower cap beams. The capping beams were also used as a springing for the sloping props and both these details are shown in the Figure 5. All this work was carried out by hand and represented an enormous amount of labour.

Figure 6 is an elevation showing a 13.7 metre navigation span and two adjacent 8 metre spans. Sloping struts were used to provide intermediate support to each longitudinal stringer at the third points of each span.

Except in the navigation spans the piles were also braced longitudinally between the capping beams at a level of 4.3 metres above high water level to provide more stability. A Close-up view of the sloping struts at their springing is shown in Figure 7.

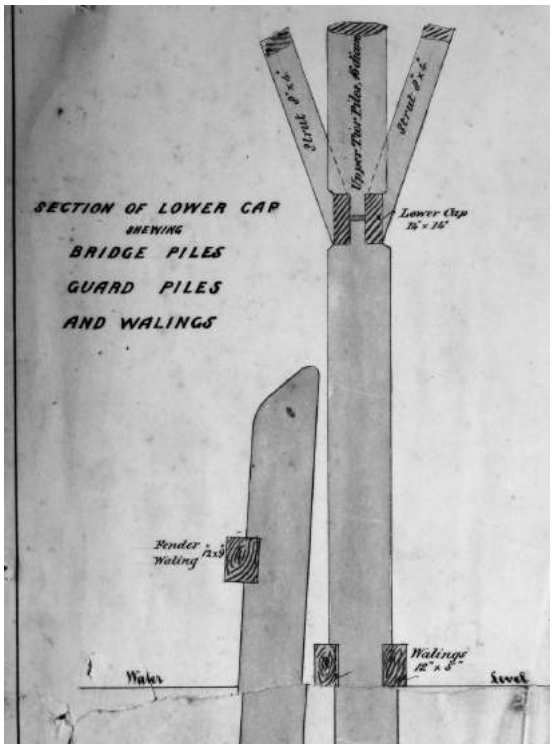

Figure 5. *Lower Cap Beam Connection*
(Courtesy of the Battye Library, Perth)

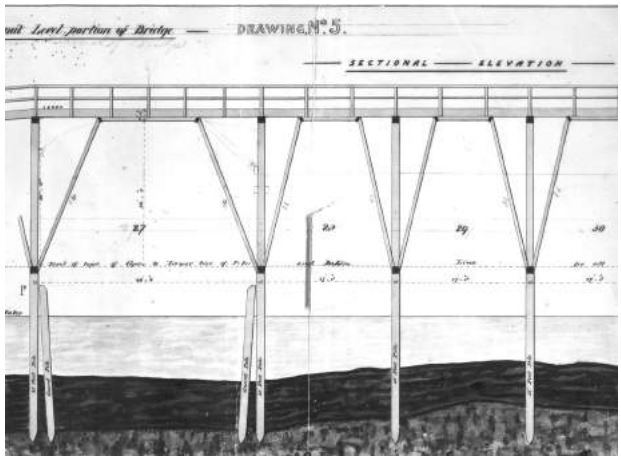

Figure 6. *Typical Bridge Spans*
(Courtesy of the Battye Library, Perth)

Figure 7. *Sloping Struts at Springing*
(Courtesy of the Battye Library, Perth)

Figure 8 is a cross section of the bridge superstructure. The timber columns were morticed into a 350x350 mm upper cap beam which supported seven 300x130 mm longitudinal stringers. The deck consisted of 180x75 mm transverse decking planks surfaced with a layer of gravel.

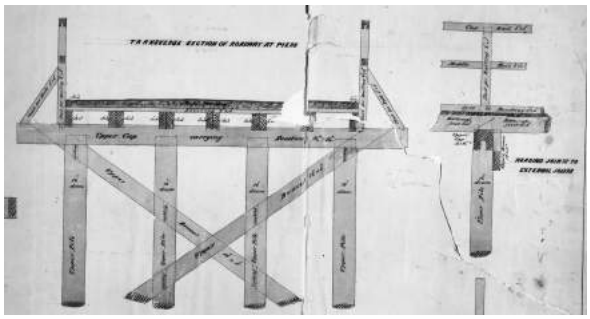

Figure 8. *Bridge Deck*
(Courtesy of the Battye Library, Perth)

The Two 13.7 metre navigation spans were strengthened by two Queen Post trusses which projected above the deck on each side of the bridge and were incorporated into the bridge railing. This form of timber truss is not the most efficient for bridges but was a standard method of construction used in the colony at that time and had earlier been employed on both the Causeway and Guildford bridges.

Figure 9 is reproduced from a drawing of the truss, signed by James Manning and dated 27th February 1869, two years after the bridge was completed.

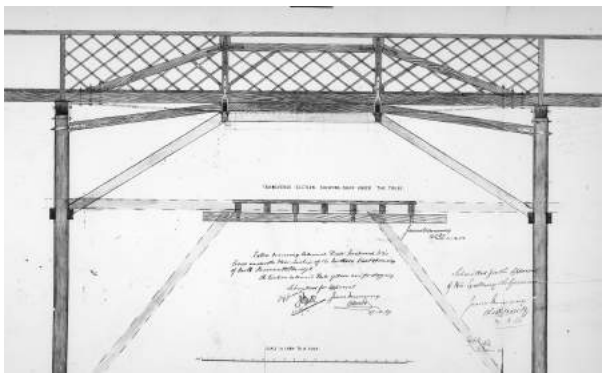

Figure 9. *Queen Post Truss over Main Spans*
(Courtesy of the Battye Library, Perth)

The truss has two vertical members at the third points of the span connected to a horizontal top chord and sloping struts on each outer third of the span, all bolted together by iron brackets. The fact that the drawing is dated almost two years after the bridge was completed and includes additional framing and a temporary platform indicates that it was produced to undertake some strengthening work to the trusses.

An enormous amount of timber was used in this bridge. In addition to the 342 round timber driven piles, some up to 17 metres in length, there was 24,000 linear metres of sawn timber. If this timber had been placed end to end in a single line it would have stretched for 24 km.

The stone arch bridge under the southern approaches to the main timber bridge mentioned earlier is of interest as it has been identified by O'Connor as one of only two masonry arch bridges ever built in WA[6]. Figure 10 is a photograph of the arch which had a span of approximately 4.3 metres.

Figure 10. *Stone Arch under South Embankment*
(Courtesy of the Battye Library, Perth)

The North Fremantle Bridge was opened to traffic at noon on Wednesday November 21, 1866 but despite the size and importance of the bridge no formal opening

ceremony was ever held. The 'Inquirer' of November 28, 1866 did however print the following amusing report of an unofficial opening:
"On Thursday evening last (that is, the night after the bridge was thrown open to traffic) our Volunteer Corps assembled on its parade ground at 8pm for a moonlight march. The strains of the band, as they marched through the town, soon attracted a numerous concourse of our inhabitants, who accompanied them to the North Fremantle Bridge, and having crossed it they, on their return, halted in the centre when Captain Manning gave a short address, the purpose of which I believe was that the bridge was a great boon to the colony, and that its want had been felt for many years; at the same time he expressed regret that it being the most important work yet to be accomplished by convict labour, and one in which so much interest had been taken by the inhabitants of Perth and Fremantle, no public rejoicings has announced its being opened. The Corps then gave three cheers for His Excellency, and marched off in a cloud of dust, raised by the juveniles who preceded them."

In 1867 the transportation of convicts to the colony was discontinued and the number of convicts steadily declined as the men worked out their sentences. The system was not finally disbanded until 1886.

4. THE FIRST RAILWAY BRIDGE

Figure 11. *1880 Railway Bridge*
(Courtesy Fremantle City Library)

The second bridge to be built in Fremantle carried a single track of the Fremantle to Guildford railway over the Swan River. Construction of the railway commenced in January 1879 and the railway was opened in March 1881. The bridge was built during 1880 and was located approximately 600 metres downstream from the High Level Bridge. It is illustrated in Figure 11 and had a length of 198 metres, made up of fifteen timber spans of 9.2 metres on the Fremantle side, which were supported by sloping struts at their third points, similar to the High Level Bridge, and four timber truss spans of 15.2 metres on the North Fremantle side.

The timber trusses used in the railway bridge had to carry the heavier rail loadings and were far more substantial than the Queen Post trusses used in the High Level Bridge. Details of the truss are shown in Figure 12. The top and bottom chords, including the sloping end-struts, were 380x400 mm in cross section while the internal bracing struts were constructed from 300x150 mm timber.

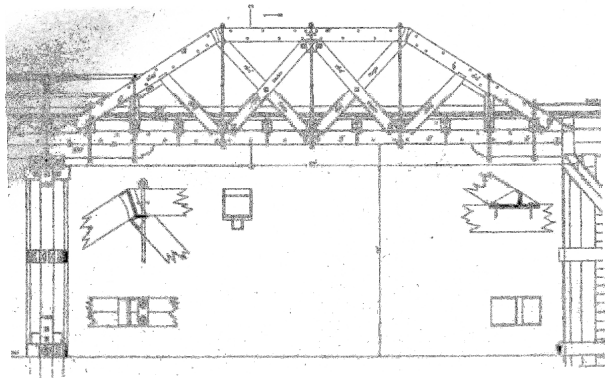

Figure 12. *15.2 m Span Timber Railway Truss*
(Courtesy of the Battye Library, Perth)

Following the construction of this first railway bridge there were major economic and political changes in the colony. In 1887 gold was discovered in the Yilgarn region near Southern Cross and further discoveries were made at Coolgardie in 1892. These discoveries led to a huge increase in the number migrants coming to Western Australia and a significant increase in economic activity. The political changes were even more momentous as Western Australia became a self-governing colony in October 1890 and in December of that year John Forrest became its first premier.

Forrest immediately embarked on an investment programme to develop basic infrastructure for the colony, such as railways, harbours and roads, and in May 1881 appointed C Y O'Connor as Chief Engineer to implement his plans. The first major project undertaken by O'Connor was the construction of a new inner harbour at Fremantle and as part of this project a

Figure 13. *Twin Railway Bridges*
(Courtesy Fremantle City Library)

second railway bridge was built on the downstream side of the existing bridge in 1895 to carry stone from the quarry at Rocky Bay to the new South Mole being constructed at Arthur Head[7]. This was the third bridge to be built and subsequently provided a second rail track

over the river for the Fremantle to Guildford railway. The twin bridges are shown in Figure 13.

5. PROBLEMS WITH THE HIGH LEVEL BRIDGE

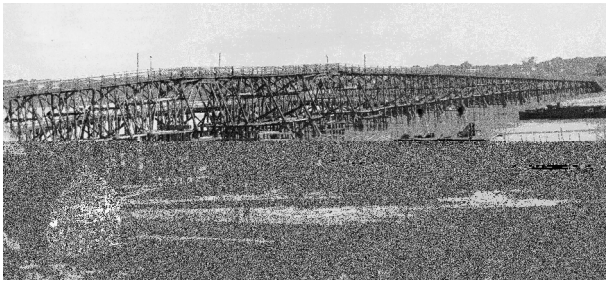

Figure 14. *High Level Bridge in 1890*
(Courtesy of the Battye Library, Perth)

In the early 1890's problems were being experienced with the High Level Bridge, another view of which is shown in Figure 14. In August 1896 a number of reports on the condition of the bridge were tabled in Parliament. Two reports, which had been prepared in 1891 and 1893, both concluded that, apart from some minor repairs required on the deck, the bridge was in sound condition. A load test was even carried out in May 1883 by driving a number of bullocks over the bridge at a fast pace and a heavily laden wagon with 2 tonnes on it. The inspection made in 1893 also included the traffic survey shown in Figure 15, which must be the first ever undertaken in Fremantle.

	Vehicles including Horses	Saddle Horses	Foot Travellers
For 6 hours	71	21	183
For rest of day	Add 50% 36	Add 50% 10	Add 160% 293
For 24 hours	107	31	476
say	140 tons	21 tons	24 tons

Figure 15. *Bridge Traffic Survey - May 1893*

A further inspection and survey undertaken in October 1896 was however far more pessimistic and reported that the bridge swayed under traffic and that even the passage of a bicycle was sufficient to throw the survey instrument off level. Problems identified in this report included shrinkage of the sloping struts, thus depriving the deck beams of their support at the third points of the spans, loose bolted connections, and timber rot in the deck. As a result of this inspection the maximum allowable load on the bridge was reduced to 1¼ tonnes and the following notice appeared in the Government Gazette:

"On and after the 27th October 1896 and until further notice, no persons shall be permitted to drive or lead any mob of cattle , camels or horses exceeding four in number over along or across this bridge or any part thereof…"

6. LOW LEVEL BRIDGE

With the greatly increased commercial activity in Fremantle this situation was obviously not acceptable and the Government decided to build a wider bridge alongside and on the downstream side of the existing bridge, but at a much lower level, and this became known as the Low level Bridge. It did however have a very awkward approach road at right angles to the bridge. The Low Level Bridge retained the same width of navigation channels but the clearance under the bridge was obviously much less, which was now acceptable because the Fremantle to Guildford Railway had replaced the old river sailing barges for the transport of goods up the Swan River. The timber trusses over the navigation spans were also more substantial than the old queen post trusses used previously. Figure 16 shows the Low Level Bridge on the left, in front of the old High Level Bridge.

Figure 16. *Low level Bridge*
(Courtesy Fremantle City Library)

The Low Level Bridge was the fourth to be built and, after it was opened on the 28th September 1898, the old bridge was closed to all except pedestrian traffic. It was intended that the low level bridge would only be a temporary structure while the old bridge was removed and replaced with a wider structure having two 23 metre navigation openings. Nothing further was done however until 1908, when the Fremantle and North Fremantle Municipal Councils wished to extend the Fremantle tramway system to North Fremantle.

The temporary low level bridge was unsuitable for a tramway as it was at the wrong level and had the awkward approach. A careful inspection was therefore made of the old High Level Bridge and it was found that out of 319 piles examined 306 were absolutely sound and the others only had minor defects which would not require them to be renewed. In view of the excellent state of the substructure of the old bridge it was decided

to renovate the superstructure and remove the low level bridge.

7. RENOVATED HIGH LEVEL BRIDGE

The deck of the High Level Bridge was removed, the piles cut down to an appropriate level, and additional piles driven to widen the bridge to allow for both road traffic and trams.

Figure 17. *Renovated High Level Bridge*
(Courtesy Fremantle City Library)

The Renovated Bridge was opened on the 18th June 1909, after which the Low Level Bridge was closed and later demolished. Figure 17 is a photograph which shows the Renovated Bridge with a tram crossing it and the low level bridge being demolished. The bridge was 10.7 metres wide and included a 7 metre wide carriageway for two lanes of motor traffic and a 3.7 metre tramway. In addition there was a 1.2 metre wide footway. The main deck was supported by 15 sawn timber stringers and 2 more stringers were provided under the footway. Larger stringers were used under the tramway to support the heavier loading. The Queen Post timber trusses spanning the two 13.7 metre navigation spans in the earlier bridge were removed and replaced with large sawn timber stringers. Sloping timber struts were provided on all the spans to support each stringer at the third points. The renovations were so extensive that I consider this to be a new bridge which therefore ranks as the fifth bridge to be built.

Apart from being re-decked in 1915 the Renovated High Level Bridge continued in service for another 30 years until December 1939, when the present bridge was opened, so the original timber piles lasted a total of 73 years.

8. THE 1926 FLOOD

The next significant event for a Fremantle Bridge occurred in 1926. In July of that year there were heavy rains in the Avon, Swan and Helena catchments which resulted in extensive flooding. The peak of the flood reached Fremantle on the 22nd July of that year and around 1pm about 30 metres of the North end of the Fremantle Railway Bridge collapsed into the river and was swept down the harbour by the flood waters. The extent of the damage is shown in Figure 18. Loosing the bridge was a major disaster for Fremantle but a far greater tragedy was only narrowly averted by the quick thinking of local workers, as described in the West Australian the following day.

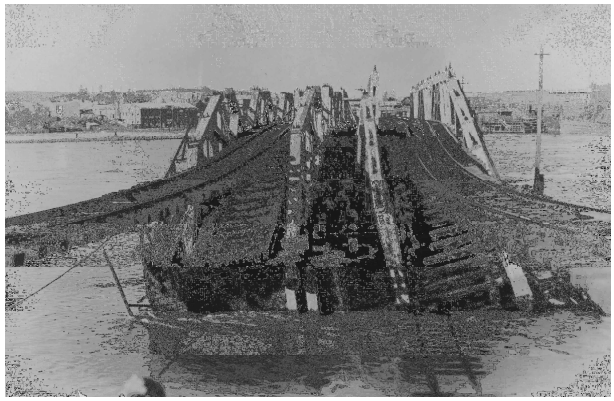

Figure 18. *Fremantle Railway Bridge – 1926 Flood Damage (Courtesy Rail Heritage WA)*

Mr Henderson, Master of the Harbour tender 'Reliance', had noticed on the day before the bridge collapse that there was a small crack in the north abutment of the bridge. The next day he was checking on the crack as the 1.12pm train from Fremantle crossed the bridge and saw the crack widen to six inches. He immediately scrambled up the embankment and shouted a warning to some men working on the train track. One of the men ran towards Fremantle and another to North Fremantle station in time to stop two trains from crossing the bridge.

After the floods the upstream of the two bridges was reconstructed in three months but the reconstruction of the second downstream bridge was not completed until April 1928, using steel beams but retaining two of the timber trusses. The lack of either railway bridge for 3 months caused considerable financial pain among Fremantle merchants as all their goods had to be diverted via Armadale and they were required to pay the additional freight costs.

9. FREMANTLE TRAFFIC BRIDGE

During the early 1930's there was increasing concern about the poor condition of the Renovated High Level Bridge and in May 1934 a complete inspection was made, including an underwater inspection by divers. This revealed that the original substructure was still sound but that there was extensive rot in the superstructure timbers which would require considerable expenditure on future maintenance. Consideration was given to replacing the bridge with a concrete structure further upstream but, because of planned future

extensions to Fremantle Harbour, a more temporary timber bridge was preferred as it would be far cheaper.

In June 1937 the Commissioner of Main Roads, Mr E. Tindale, recommended that the bridge be replaced by a new timber bridge immediately downstream of the existing bridge at an estimated cost of £75,000. Government approval was given and the present Fremantle Traffic Bridge was opened on the 15th December 1939 by the then Premier, J.C. Willcock. The opening coincided with the completion of the Stirling Highway and a change in public transport from trams to buses.

Figure 19. *Fremantle Traffic Bridge*
(Courtesy Fremantle City Library)

The bridge has a total length of 205.5 metres, made up of one steel span of 12.2 metres over Beach Street, 22 timber spans of 6.1 metres plus three central navigation spans supported by steel girders, two of 21 metres and a central one of 17.1 metres. It was designed by the Main Roads Bridge Engineer, Mr E. W. Godfrey, and was the seventh bridge to be built in Fremantle.

Figure 19 is a photograph taken in the 1940's, looking towards North Fremantle, and shows the old Renovated High Level Bridge just upstream. When the new bridge was opened there was concern that Fremantle could be subject to bomb attacks and the old bridge was left standing for emergency use and was not finally demolished until 1947.

10. ROUND TIMBERS IN ROAD BRIDGES

The Fremantle Traffic Bridge was the first timber bridge to be built over the Swan River at this site using round timber instead of sawn timber stringers. After the High Level Bridge was built by Manning considerable advances occurred in the design of timber bridges. After the convict system was disbanded in 1886 the construction of bridges on public roads became the responsibility of the Public Works Department, who continued to use sawn timber stringers but increased their size so they could span 6.1 metres between piers without the need for sloping struts within the spans. These bridges were designed for a maximum axle load of 6.8 tonnes.

In 1926 responsibility for roads and bridges passed to a Main Roads Board and they made a major change to the design of timber bridges in 1928 by using round timber Jarrah logs instead of sawn timber for the stringers. These had a mid-span diameter of 460 mm and spanned 6.1 metres between piers. This design provided for a maximum axle load of 10 tonnes and remained the standard until 1945, when the mid-span diameter of the stringers was increased to 530 mm to carry a higher design loading of 20 tonnes.

The construction of these timber bridges is relatively simple but it did require special skills by timber workers and these skills have largely been lost in recent times. The last timber bridge was built by Main Roads in 1994 and, although maintenance of existing timber bridges will continue for many years, it is unlikely that they will build any new timber bridges. A detailed description of timber bridges is given in an earlier paper by the author[8] but Figures 20 to 22 have been included to illustrate their construction. Figure 20 is an elevation showing the layout and details of a typical bridge. Figure 21 is a photograph of a timber bridge during construction.

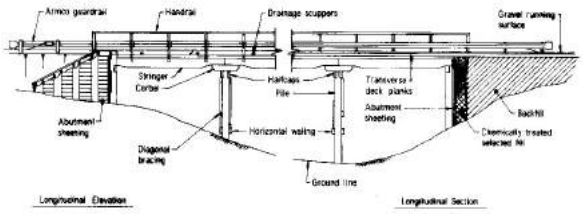

Figure 20. *Typical Timber Bridge*

The flat seatings on the timber corbels and stringers were shaped by hand using a broadaxe and this operation is shown in Figure 22.

Figure 21. *Timber Bridge under Construction*

Figure 22. *Timber Stringers Being Shaped by Broadaxe*

11. EXISTING BRIDGES

Figure 23. *Aerial View of Existing Bridges*
(Courtesy of the Battye Library, Perth)

Figure 23 is an aerial photograph, taken in February 1975, which shows all three existing bridges in Fremantle, two of which have been built relatively recently. On the left is the present railway bridge and adjacent to this is the existing Traffic Bridge and on the right is Stirling Bridge.

11.1 Railway Bridge

The present railway bridge was built in 1964 to replace the two old timber bridges which had been in service since the 1880's. The new bridge was relocated upstream of the earlier timber bridges, adjacent to the existing Traffic Bridge. It was designed by Maunsell and partners, who had earlier designed the Perth Narrows Bridge, and consists of concrete piers supporting two rail tracks on steel girders. The bridge was a standard type design for its time and was the seventh bridge to be built since 1863. It was opened on the 14th September 1964. Figure 24 shows the bridge being test loaded prior to being opened to traffic.

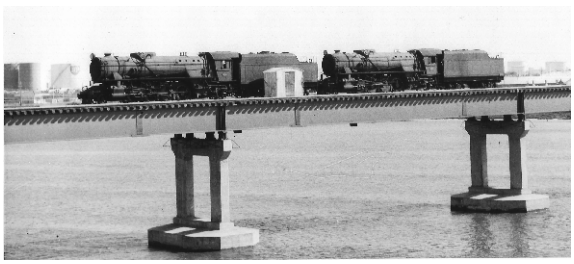

Figure 24. *Test Load on Railway Bridge*
(Courtesy Rail Heritage WA)

11.2 Stirling Bridge

The most recent bridge to be built is the Stirling Bridge. This was also designed by Maunsell and Partners and was constructed by West Australian Contractor J.O. Clough & Son. It is of historical interest because it was the first prestressed concrete bridge to be built in Fremantle using modern construction techniques quite different from any of the earlier bridges.

The method used to construct the bridge is shown in Figure 25. The whole deck is made up of individual precast concrete units which were supported on temporary girders before being prestressed together into a continuous beam for each span. Hollow ducts had previously been cast into the individual precast concrete units and, when these had been assembled into a whole span, high strength steel cables were threaded through the ducts and prestressed with a jacking force of 350 tonnes then anchored at each end to permanently maintain the prestress force in the bridge.

Figure 25. *Stirling Bridge during Construction*

Figure 26. *Stirling Bridge*

Figure 26 shows the completed bridge, which was opened on the 17th May 1974 by the then Premier, Sir Charles Court. The bridge has six spans with a total length of 350 metres and the deck profile is not horizontal but rises 4.6 metres on a uniform curve from the north to the south abutment. The span lengths vary from 47m at the north abutment to 81m at the south abutment, with a corresponding increase in beam depth from 1.8m at the lower end to 3.4 metres at the higher end, in order to make the underside of the bridge appear more level with the river and enhance appearance of the bridge.

When the bridge was opened it was the longest bridge in Western Australia and is a fine example of a twentieth century bridge.

12. CONCLUSIONS

Only three of the eight bridges built over the Swan River still exist as the other five have all been demolished. This is quite a common occurrence as most bridges have a limited life, due to structural weakness or changes in community requirements. Retaining redundant bridges because of their heritage value is very seldom a feasible option. This paper has endeavoured to show that the heritage value of such structures does not have to be lost and that by collecting appropriate written and visual records it can be preserved for the future.

12. REFERENCES

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